Development of Meandering Winding Magnetometer (MWM®) Eddy Current Sensors for the Health Monitoring, Modeling and Damage Detection of High Temperature Composite Materials

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Abstract

The increased use of high-temperature composite materials in modern and next generation aircraft and spacecraft have led to the need for improved nondestructive evaluation and health monitoring techniques. Such technologies are desirable to improve quality control, damage detection, stress evaluation and temperature measurement capabilities. Novel eddy current sensors and sensor arrays, such as Meandering Winding Magnetometers (MWMs) have provided alternate or complimentary techniques to ultrasound and thermography for both nondestructive evaluation (NDE) and structural health monitoring (SHM). This includes imaging of composite material quality, damage detection and the monitoring of fiber temperatures and multidirectional stresses.

Historically, implementation of MWM technology for the inspection of the Space Shuttle Orbiter Reinforced Carbon-Carbon Composite (RCC) leading edge panels was developed by JENTEK Sensors and was subsequently transitioned by NASA as an operational pre and post flight in-situ inspection at the Kennedy Space Center. A manual scanner, which conformed automatically to the curvature of the RCC panels was developed and used as a secondary technique if a defect was found during an infrared thermography screening. During a recent proof of concept study on composite overwrapped pressure vessels (COPV's), three different MWM sensors were tested at three orientations to demonstrate the ability of the technology to measure stresses at various fiber orientations and depths. These results showed excellent correlation with actual surface strain gage measurements. Recent advancements of this technology have been made applying MWM sensor technology for scanning COPVs for mechanical damage.

This presentation will outline the recent advances in the MWM technology and the development of MWM techniques for NDE and SHM of carbon wrapped composite overwrapped pressure vessels (COPVs) including the measurement of internal stresses via a surface mounted sensor array. In addition, this paper will outline recent efforts to produce sensors capable of making real-time measurements at temperatures up to 850 C, and discuss previous results demonstrating capability to monitor carbon fiber temperature changes within a composite material.